



Discovery

An experimental analysis on cooking performance of parabolic solar cooker in Kathmandu valley

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ABSTRACT

In the present context, the world's population is increasing day by day. Due to rapid increment in population, demand for energy is increasing. The challenge towards fuel crisis is also increasing. The habitual use on energy consumption will not be comprised even if all the fossil fuel gets exhausted. After fossil fuels, people will obviously move in forest resources for the supplement of energy needs. So its necessity to find an alternative energy resource that can be replenished constantly and forest resources can be

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conserved making environment clean and healthy. Now it's high time for us to focus on promotion of the alternative source of energy. Among renewable energy sources sun's energy comes in first choice. The sun's energy is really powerful. Solar energy is renewable and it's free of cost. In the context of our country Nepal, where majority of population are dependent on firewood, biomass, cow-dung for cooking purposes, solar cooking can be better choice for reducing such energy resources. The study focuses on the usage of solar energy. The study on experimental analysis on cooking performance of Parabolic Solar cooker in Kathmandu valley was carried out to identify the cooking performance using anodized pressure cooker and time at which cooking time can be fast. From the result, it was found that cooking could be efficient in daytime so it could be used in hotels in Himalayan region, trekking zone where firewood is not much available. And cooking process in parabolic solar cooker was not so slow that it couldn't be used. The taste of food was relatively better than that of cooked in firewood and liquefied petroleum gas as food retains tenderness in it.

Keywords: Solar Energy, solar cooking technology, parabolic solar cooker, energy savings

1. INTRODUCTION

The world has been taking huge leaps of progress in the development in every second. Such a boon development has equally high cost in the form of energy. Currently there are many resources of energy and we use such resources of energy for cooking, lightening our houses, warming, and industrial uses, and for many daily and necessary purposes [1]. Around the world, since long time the use of fossil fuels have become main energy sources. As per the records of World Bank in 2012, among all the available energy sources 81.1% of fossil fuels are consumed for the energy needs [2]. Fossil fuels are generated from the remains of several organisms deposited from millions of millions years past. As the population is increasing day by day, the needs for energy is also increasing. If the rate of energy consumption increases continuously, the fossil fuels will certainly exhausted resulting in energy crisis in near future. As fossil fuels are limited in quantity, humans are in no condition for further reliance on fossil fuels as a major source of energy. On the other hand, the burning of such fossil fuels release the harmful gases such as carbon dioxide, nitrogen oxides, aerosols etc. which have well known adverse impacts on public health and environment. Moreover conflicts between countries and political issues may also arise due to shortage of fossil fuels [3-5].

As fossil fuels are not the perpetual source of energy and crisis will surely come in future and when the situation will incur people will move to firewood as alternatives of cooking. Heavy use of firewood will create a massive depletion of forests resulting to deforestation and global warming along with natural disasters such as drought, flood, and landslide. Apart from global warming effects, deforestation and other environmental effects, people suffers from many serious health issues such as burns, eye disorder and lung diseases. So, in order to avoid such harmful effects on environment, public health, economic and sociological condition, it's a time to research about an alternative renewable source of energy that is reliable so that dependency on fossil fuel will decrease.

Among such renewable alternatives solar energy can be one of the effective energy sources. Solar energy is the energy that comes from sun in the form of solar radiation. The surface of the earth experiences the sunlight from the sun having power equivalent to 1.5×10^{18} KWH annually, which is equivalent to 1.9×10^{14} ton coal equivalent (tce)[3].

As per the context of Nepal, Nepal is introduced as a small landlocked country with high Himalayas and majestic mountains [6]. The word landlocked itself defines the country which has no access to any sea or ocean. Further, till the date today, country owns no mines of coal, petroleum resources and other fossil fuels and should rely on other countries. Many people of rural areas and villages use traditional energy sources like firewood (76.3%), agricultural waste (11.1%) and animal dungs (8.5%); primarily used for cooking and space heating which have degraded the environment [7]. Recently (2015/16), Nepal had faced problem of blockade of around 6 months with its southern borders, the only borders for transportation of fossil fuels. This blockade had taught a great lesson to Nepalese citizen about the importance of fossil fuels and forecasted energy crisis. Blockade had created very huge loss to the nation in terms of its economic growth and social life. With the blockade legs were seen to be the kings of roads and houses were surrounded with smoke all around. Herein legs are symbolized as king's legs because in that time very few running vehicles were seen and houses were surrounded with smokes as in most of the houses firewood were used as cooking fuel due to shortage of LPG. This blockade showed the image of consequences to be faced by the nation when actually there will be the situation of fuel crisis all over the world. So renewable energy sources like solar, wind, biogas should be thought as energy sources.

Solar energy can be useful in Nepal. In the world map, Nepal is located at favorable solar belt and per year 2556 hours of sunlight have been noticed. Solar energy potential in Nepal is about 26000 MW. Nepal has 4.7 kW /h/m²/day solar isolation [8]. So, there are possibilities of using such huge amount of energy in many ways. The utilization of solar energy can be useful to resolve the problem and decrease dependency on fossil fuels and firewood for household purposes. For this, solar cooking can be one of the options by using solar cooker.

Solar cooker is a simple device that uses sun's rays to cook food. The concept of solar cooking was introduced from the ancient time. The solar cooker was first built by Swiss naturalist Horace de Saussure (Father of solar cooking) by building a small container in which he cooked fruits using only sunshine and obtained the temperatures of 189.5 degree Fahrenheit in 1767. His experiment paved the way for further investigations [9]. Around the world, many scientist and engineers are investigating in the production of modern and highly efficient design of solar cooker and many organizations, renewable energy centers are working in distribution and promotion of solar cookers in the area where it can work effectively. The box type, funnel shaped, panel type, parabolic shaped and vacuum tube technology (advanced type) are mainly five types of solar cooker so far used in this world. Here for the experiment parabolic shaped solar cooker was used [10].

This work consists of 4 sections including introduction, divided according to our concept to better understand the present study. Section 2 discusses the instrumentation, while section 3 presents the results and discussion and the conclusion is given in section 4.

2. INSTRUMENTATION

In this section, we will describe about the instrumentation used in this research. For this work, we had used parabolic solar cooker, anodized pressure cooker painted black with induction base, wall thermometer, laboratory thermometer, and sample food items to test. The detail information is given below,

Parabolic solar cooker

A parabolic solar cooker of model SUNKING SC-1500 was used as an experimental material to cook food [11, 12]. The technical speciation of parabolic solar cooker used can be seen in Table.1.

Table 1 Technical Specification of parabolic solar cooker used

DESCRIPTION	SPECIFICATION
Model	SUNKING SC-1500
Disc material	0.6mm thick carbon steel sheet
Reflector material	Vacuum aluminum film
Disc diameter	1500mm
Reflector area	1.77 m ²
Focus Point	700 mm
Power output in good sunny day	1000-1500W
Height of pot stand from floor	1100mm
Maximum load weight	25Kg
Stand material	Powder Coated mild steel section
Disc tracking movement	Manual, Adjustment required every 10-15 minutes
Net Weight	15.5 kg
Gross Weight	16 kg
Packing size and material	700 x 760 x 120 mm, carton packing

Anodized pressure cooker painted black with induction base

Russian Scientist first developed the anodizing to produce a metal surface tough for space travel. Then the same technology is used in pressure cooker. In hard anodizing process, electrolysis is done at sub-zero temperature using high intensity electric current. Here,

a 60 micron thick layer of aluminum oxide (Al_2O_3) is formed by molecule as a part of pure, virgin aluminum. It produces a tough surface with wonderful properties of cooking. An induction compatible disc is attached under a high pressure to ensure base that is permanent and heats quickly and evenly. Black coating helps to have minimum heat loss.

The pressure cooker used was of HAWKINS brand and has following properties:

- Thermally efficient: heats fast and evenly,
- Not spoilt by high heat,
- times harder than steel,
- Non-toxic, non-staining, non-reactive with foods,
- Will not pit, tarnish or corrode,

With the use of anodized pressure cooker painted black with induction base, a parabolic solar cooker can be more effective in cooking.

Wall Thermometer, Laboratory Thermometer and Sample food items to test

The wall thermometer was used to measure surrounding temperature. The laboratory thermometer capable of reading temperature from 0°C to 360°C was taken. The food items were 2litres of water, ½ litres of milk, 6 eggs, 0.5kg potatoes, 0.5litres lentils, 0.5kg meat, some green leafy vegetables, and 0.5kg rice.

3. RESULTS AND DISCUSSION

In this section we describe in detail about the boiling test and performance of cooking test. The detail descriptions of the events are as follows.

Case 1: Water boiling test performed on June 3, 2016:

Solar cooking means cooking with sun's power. Experiment was carried out in the ground of AEPC where direct sunlight radiation comes. In water boiling test, 2 litres of water was taken and boiled on parabolic solar cooker of model SUNKING SC-1500. Time taken to boil was noted. This process was repeated from late-morning to late noon.

Table 2 Water boiling test on parabolic solar cooker on June3, 2016

	TIME	SURROUNDING TEMPERATURE	TIME REQUIRED TO BOIL WATER
LATE MORNING	9:15A.M - 9:45A.M	23°C	20 minutes
	10:00A.M - 10:20A.M	22°C	20 minutes
	10:30A.M -10:48 A.M	25°C	18 minutes
	10:50A.M - 11:07A.M	26°C	17 minutes
AFTERNOON	11:10A.M - 11:25A.M	28°C	15 minutes
	11:30A.M -11:45 A.M	30°C	15minutes
	11:50A.M - 12:04P.M	33°C	14 minutes
	12:10P.M- 12:23P.M	34°C	12 minutes
	12:30P.M - 12:42P.M	35°C	12 minutes
	12:50 P.M- 13:02P.M	36°C	12 minutes
	13:15P.M - 13:26P.M	36°C	11 minutes
	13:30 P.M - 13:42P.M	36°C	12 minutes
	14:00P.M - 14:12P.M	35°C	12 minutes
	14:20P.M - 14:33P.M	33°C	13 minutes
EARLY NOON	14:40 P.M - 14:55P.M	35°C	15 minutes
	15:00P.M - 15:15P.M	30°C	15minutes
	15:30P.M -15:48P.M	29°C	18 minutes
	16:00P.M - 16:22P.M	29°C	22 minutes

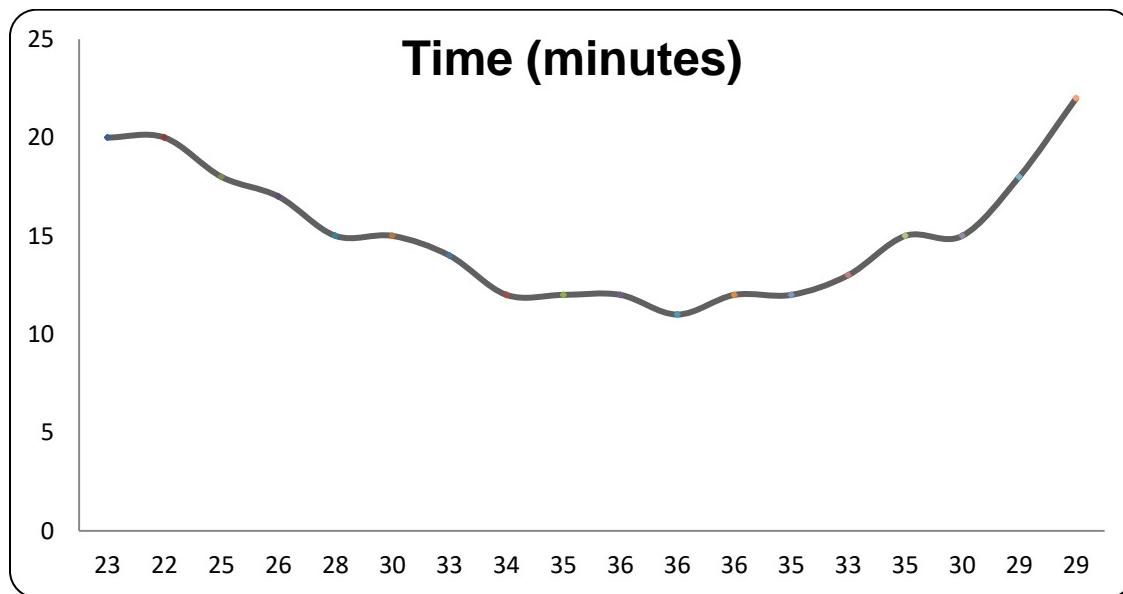


Figure 1 Variation of boiling time of water with surrounding temperature

Above table 2 lists the data collected during field work and figure 1 showed the variation in boiling time of water with surrounding temperature. Considering the variation of boiling time of water with surrounding temperature, it had been concluded that the boiling time of water was indirectly proportional with the surrounding temperature. From the figure above, it was observed that there was rise in temperature as time passes till about 2 P.M. and boiling time of water was decreased and again with slow decrease in surrounding temperature, the time started to increase slowly.

Case 2: Cooking test performed on June 18, 2016

Different food items which are mainly cooked in every house were selected.

Table 3 Cooking performance of parabolic solar cooker on June 18, 2016

FOOD PREPARED	QUANTITY/ITEMS	AMBIDENT TEMPERATURE	MAXIMUM PLATE TEMPERATURE ATTAINED BY POT AT	TIME TAKEN TO COOK FOOD
MILK	0.5 litres	35°C	180°C	8 minutes
EGGS	6 pcs	33°C	160°C	15 minutes
POTATOES	0.5kg	33°C	140°C	20 minutes
RICE	0.5kg	34°C	185°C	25 minutes
LENTILS	0.5 litres	36°C	195°C	21 minutes
MEAT	0.5kg	36°C	220°C	45 minutes
GREEN LEAFY VEGETABLES	Some	35°C	135°C	6 minutes

Case 3: Cooking test performed on June 28, 2016

By carrying out experimental observation only in one day the result obtained cannot be valid and reliable so same experiment was carried out in another day at the same ground.

Table 4 Cooking performance of parabolic solar cooker on June 28, 2016

FOOD PREPARED	QUANTITY/ITEMS	AMBIENT TEMPERATURE	MAXIMUM PLATE TEMPERATURE ATTAINED BY POT AT FOCUS	TIME TAKEN TO COOK FOOD
MILK	0.5 litres	31°C	110°C	10 minutes
EGGS	6 pcs	30°C	140°C	20 minutes
POTATOES	0.5kg	31°C	130°C	22 minutes
RICE	0.5kg	34°C	210°C	30 minutes
LENTILS	0.5 litres	36°C	130°C	20 minutes
MEAT	0.5kg	35°C	220°C	48minutes
GREEN LEAFY VEGETABLES	Some	35°C	80°C	6 minutes

In parabolic solar cooker of model SUNKING SC-1500, water boiling test and cooking test by using anodized pressure cooker were observed in the ground of AEPC, Khumaltar, Kathmandu. After water boiling test carried out on June 3 2016, the study revealed that, at late morning it considerably takes long period of time while at afternoon, water boils at very short duration. If we look at late noon of the day, boiling time of water again increases. In late morning at about from 9:15A.M to 11:00A.M, duration of boiling time of water was long about 20 to 17 minutes with surrounding temperature ranging from 23°C to 28°C. As the time passes, the sun starts to become direct to the earth (direct solar flux) and the sun's power also increases, surrounding temperature also becomes warmer and then focus of light to the pot increases and hence boiling time of water decreases. From the study, it was revealed that after 11:00A.M to 14:55P.M, boiling time of water decreases from 15 minutes to 11 minutes and surrounding temperature ranges from 28°C to 36°C. The shortest duration of time to boil water was obtained as 11minutes in around 13:15P.M to 13:26P.M. In between 12:00P.M to 13:41P.M boiling time of water was reported as 12 minutes. Then boiling time progressively increases in late afternoon. During 4'oclock duration for maximum time was recorded as 22 minutes. From this study, it was found that solar cooking is favorable during day time and there was not much difference also. So if we focus the sun's radiation correctly, cooking can be performed efficiently.

Cooking test performance test were carried out in two days to make data valid and reliable. During cooking performance in both times cooking duration for chosen items was almost same. The temperature was also almost same in both days. On the observation carried out in June 18, 0.5 litres of milk was boiled in 8 minutes, 6 pcs of eggs became ready to eat after 15 minutes, 0.5kg of potatoes boiled in 20 minutes and rice was cooked in 25 minutes. Similarly 0.5 litres of lentils was cooked in 21 minutes and green leafy vegetables in 6 minutes. As meat takes longer time to cook in normal gas also so here in parabolic solar cooker also it took 45 minutes to cook. The maximum pot temperature was noted during cooking of meat was 220°C. And the meat was cooked in mid-day.

Similarly on June 28, milk took 10 minutes to boil, eggs required 20 minutes to boil, potatoes required 22 minutes to boil, rice required 30 minutes to boil, lentils required 20 minutes, meat required 48 minutes and green leafy vegetables required only 6 minutes. The maximum pot temperature noted during cooking was 110°C, 140°C, 130°C, 210°C, 130°C, 220°C and 80°C respectively. Hence maximum pot temperature was noted during cooking of meat was 220°C.

From this study, it was revealed that during cooking the pot temperature can be reached to 220°C in parabolic solar cooker of model SUNKING SC-1500 in good sunny day when carried out in Kathmandu valley.

4. CONCLUSION

A parabolic solar cooker of model SUNKING SC-1500 was used as an experimental material to cook food. While carrying out boiling test, it was found that solar cooking is favorable during day time and there is not much difference also. So if we focus correctly cooking can be performed efficiently. So it could be properly used to pasteurize water also which could prevent many people from water borne diseases. And to perform cooking performance, cooking tests were done during day time on June 18 and June 28, 2016. While carrying out cooking test, ½ litres of milk, 6eggs, 0.5kg potatoes, 0.5litres lentils, 0.5kg meat, some green leafy vegetables, and 0.5kg rice were taken with thought in mind that of daily cooking materials in every home.

According to the dealer of Solar Company the market price of solar cooker was Rs.8000. And it was of Chinese model. It was also an environment friendly. The model was based on a very simple principle of a law of reflection in parabola and it was folding and hence it was easy to maintain and repair and it could also be placed in any place where direct sunlight comes with our own will. The food could be cooked in time not much less than that of in LPG. In the parabolic solar cooker we used it could retain high degree temperature than that of other type of solar cooker like box type. The experiment was carried out in Kathmandu valley in the month of June. From the results of cooking performance obtained from the parabolic solar cooker that we selected, it could be concluded that the sun's radiation is good and favorable for solar cooking in the Kathmandu valley. This type of solar cooker could be used both in the rural and urban areas. In the remote areas where there were no facility of modern means of cooking and for the poor people who could not spend money in fossil fuels and had to become fully dependent on firewood resulting in depletion of forest resources, various respiratory diseases like pneumonia, lungs problem and burning issues for women and children, solar cooking could be suitable option as by the use of this parabolic solar cooker, people could maintain their health, managed their time, conserve forest resources and maintain ecological biodiversity and it didn't require recurring cost so for poor people, if once bought or if some agencies gifted, it could be used for long time. Similarly in Himalayan region, due to less development the one of the highly preferred cooking fuel is firewood and there is scarcity of firewood due to less forest resources so society women and children had to spend their time in search of firewood in which they can do other valuable work. And the sun's radiation is much powerful so there is also a possibility of solar cooking which could be used to cook food in homes, hotels, trekking centers etc. Also, in the urban sector it would save energy on kerosene and LPG and would make our cooking easy.

The fossil fuels like kerosene, LPG are non-renewable and will be in situation of exhausting in future and our country depends on fossil fuel for other countries so, if solar cooker comes in use as an additional fuel at first and later as a substitute then our country would become self-dependent for energy resources resulting in saving of foreign currency.

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